

ROTATION PERIOD OF MARS.—Mr. W. F. Denning has recently secured some measures of the times of transit of the Syrtis Major (Kayser Sea), which in conjunction with observations made by him in 1884 and 1869 give a critical value for the period (*Observatory*, May 1899, p. 195). On February 4, 1869, the Syrtis Major was in mid-transit at 11h., while on February 14, 1884, when Mars was similarly situated with reference to the Earth, the transit occurred at 5h. 55m. Other transits were taken as February 15, 6h. 35m.; February 19, 9h. 5m.; February 22, 11h. 4m. Now, after another interval of fifteen years, the transit on March 7, 1899, occurred at 8h. 31m. The whole period between 1869 February 4, 11h. and 1899 March 7, 8h. 31m., comprises 10,987 days, 21 hours, 31 minutes, during which Mars has performed 10,710 rotations. The mean period during this interval thus becomes

24h. 37m. 22⁷/₁₀s.

This value is intermediate between those of Proctor and Bakhuyzen.

AN IMPROVED RESISTANCE-BOX.

MESSRS. GAMBRELL BROS. have recently introduced a resistance-box of improved design, which gives promise of eliminating several of the disadvantages of the usual post-office pattern. Fig. 1 shows the appearance of the box with the cover removed to show the working parts. The coils, which hang vertically in the lower part of the box, are brought up to

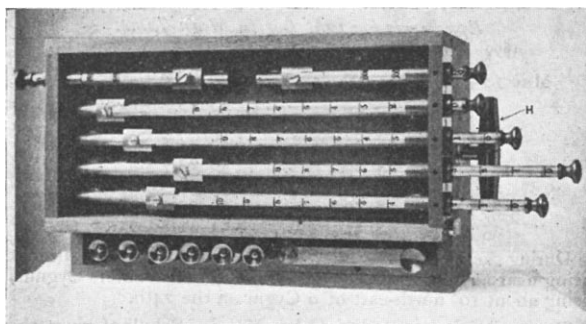


FIG. 1.—General view of the box, from above, showing the numbered slide rods, the contact shoes and the terminal studs of the coils. The handle (H) at the right is for clamping all the contact shoes simultaneously.

terminal studs (T) seen in Fig. 2, arranged in five rows, one of which, in two sections, forms the "ratios" used as two arms of the bridge. The upper surfaces of these studs are semi-circular, fitting the concave surfaces of the sliding contact shoes (S). The four rows other than the "ratios" provided for thousands, hundreds, tens and units, reckoned from the side nearest the terminals and key. Each of these contact shoes slides with slight friction on a brass bar running the length of the box, and supported at each end by metal pillars held down by springs inside the box. To move the shoes from one stud to another other

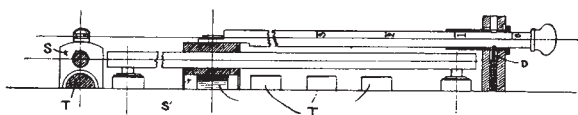


FIG. 2.—Showing construction of slider, spring contact bar, &c.

brass rods are attached, which slide through ebonite bushes on the end of the box. On these rods are engraved the figures giving the amount of resistance in use, the value of any particular resistance in circuit being indicated by the number showing just outside the ebonite bush. To ensure the contact shoe being properly fixed on the studs, a spring detent (D, Fig. 2) is provided under each bar, so that the resistances may be changed without the experimenter needing to watch the bar. All the bars being arranged to give the resistance required, it will be evident that its total amount can be read straight off at the end

of the box, being given by the row of figures close to the four ebonite bushes. For example, the reading of the resistance in circuit, as shown in Fig. 1, is 2310. This is itself a great convenience, and will prevent any chance error in adding. As an additional help to maintaining the contacts as constant and perfect as possible, when the proper resistance has been found, all the four shoes are drawn tightly down on to the terminal studs by turning the handle H, seen under the ends of the rods in Fig. 1. This actuates a cam inside, which moves the small pillars at each end of the brass bars passing through the contact shoes. At the same time, the arrangement acts as a clamp, so that while the handle is turned the resistances cannot be changed. All the pillars are held down by springs, so that when not clamped by the handle H the sliding to and fro is accompanied by sufficient friction to keep the contact surfaces clean.

In consequence of the ingenious method adopted for reading off the figures, rendering access to the contacts themselves quite unnecessary, the whole of the system of studs and sliding bars is covered in permanently, so that they and the ebonite insulating block are kept free from dust and corrosion. The studs, being a considerable distance apart, should permit of a very high insulation resistance, while at the same time allowing a large surface contact between the shoe and the stud.

It will be seen that this new form of box has many advantages to recommend it to notice. The simplicity and rapidity of reading, its compactness, and its non-liability to deterioration, should cause it to find favour both in laboratory and testing-room experience.

TRANSPARENCY AND OPACITY.¹

ONE kind of opacity is due to absorption; but the lecture dealt rather with that deficiency of transparency which depends upon irregular reflections and refractions. One of the best examples is that met with in Christiansen's experiment. Powdered glass, all from one piece and free from dirt, is placed in a bottle with parallel flat sides. In this state it is quite opaque; but if the interstices between the fragments are filled up with a liquid mixture of bisulphide of carbon and benzole, carefully adjusted so as to be of equal refractivity with the glass, the mass becomes optically homogeneous, and therefore transparent. In consequence, however, of the different dispersive powers of the two substances, the adjustment is good for one part only of the spectrum, other parts being scattered in transmission much as if no liquid were employed, though, of course, in a less degree. The consequence is that a small source of light, backed preferably by a dark ground, is seen in its natural outlines but strongly coloured. The colour depends upon the precise composition of the liquid, and further varies with the temperature, a few degrees of warmth sufficing to cause a transition from red through yellow to green.

The lecturer had long been aware that the light regularly transmitted through a stratum from 15 to 20 mm. thick was of a high degree of purity, but it was only recently that he found to his astonishment, as the result of a more particular observation, that the range of refrangibility included was but two and a half times that embraced by the two D-lines. The poverty of general effect, when the darkness of the background is not attended to, was thus explained, for the highly monochromatic and accordingly attenuated light from the special source is then overlaid by diffused light of other colours.

More precise determinations of the range of light transmitted were subsequently effected with thinner strata of glass powder contained in cells formed of parallel glass. The cell may be placed between the prisms of the spectroscopie and the object-glass of the collimator. With the above-mentioned liquids a stratum 5 mm. thick transmitted, without appreciable disturbance, a range of the spectrum measured by 11³/₁₀ times the interval of the D's. In another cell of the same thickness an effort was made to reduce the difference of dispersive powers. To this end the powder was of plate glass and the liquid oil of cedar-wood adjusted with a little bisulphide of carbon. The general transparency of this cell was the highest yet observed. When it was tested upon the spectrum, the range of refrangibility transmitted was estimated at thirty-four times the interval of the D's.

As regards the substitution of other transparent solid material

¹ A discourse delivered at the Royal Institution on Friday, March 24, by the Right Hon. Lord Rayleigh, F.R.S.

for glass, the choice is restricted by the presumed necessity of avoiding appreciable double refraction. Common salt is singly refracting, but attempts to use it were not successful. Opaque patches always interfered. With the idea that these might be due to included mother liquor, the salt was heated to incipient redness, but with little advantage. Transparent rock-salt artificially broken may, however, be used with good effect, but there is some difficulty in preventing the approximately rectangular fragments from arranging themselves too closely.

The principle of evanescent refraction may also be applied to the spectroscope. Some twenty years ago an instrument had been constructed upon this plan. Twelve 90° prisms of Chance's "dense flint" were cemented in a row upon a strip of glass (Fig. 1), and the whole was immersed in a liquid mixture of bisulphide of carbon with a little benzole. The dispersive power of the liquid exceeds that of the solid, and the difference amounts to about three-quarters of the dispersive power of Chance's "extra dense flint." The resolving power of the latter glass is measured by the number of centimetres of available thickness, if we take the power required to resolve the D-lines as unity. The compound spectroscope had an available thickness of 12 inches or 30 cm., so that its theoretical resolving power (in the yellow region of the spectrum) would be about 22. With the aid of a reflector the prism could be used twice over, and then the resolving power is doubled.

One of the objections to a spectroscope depending upon bisulphide of carbon is the sensitiveness to temperature. In the ordinary arrangement of prisms the refracting edges are vertical. If, as often happens, the upper part of a fluid prism is warmer than the lower, the definition is ruined, one degree (Centigrade) of temperature making nine times as great a difference of refraction as a passage from D_1 to D_2 . The objection is to a great extent obviated by so mounting the compound prism that the refracting edges are horizontal, which of course entails a



FIG. 1.

horizontal slit. The disturbance due to a stratified temperature is then largely compensated by a change of focus.

In the instrument above described the dispersive power is great—the D-lines are seen widely separated with the naked eye—but the aperture is inconveniently small ($\frac{1}{3}$ -inch). In the new instrument exhibited, the prisms (supplied by Messrs. Watson) are larger, so that a line of ten prisms occupies 20 inches. Thus, while the resolving power is much greater, the dispersion is less than before.

In the course of the lecture the instrument was applied to show the duplicity of the reversed soda lines. The interval on the screen between the centres of the dark lines was about half an inch.

It is instructive to compare the action of the glass powder with that of the spectroscope. In the latter the disposition of the prisms is regular, and in passing from one edge of the beam to the other there is complete substitution of liquid for glass over the whole length. For one kind of light there is no relative retardation; and the resolving power depends upon the question of what change of wave-length is required in order that its relative retardation may be altered from zero to the quarter wave-length. All kinds of light for which the relative retardation is less than this remain mixed. In the case of the powder we have similar questions to consider. For one kind of light the medium is optically homogeneous, *i.e.* the retardation is the same along all rays. If we now suppose the quality of the light slightly varied, the retardation is no longer precisely the same along all rays; but if the variation from the mean falls short of the quarter wave-length it is without importance, and the medium still behaves practically as if it were homogeneous. The difference between the action of the powder and that of the regular prisms in the spectroscope depends upon this, that in the latter there is complete substitution of glass for liquid along the extreme rays, while in the former the paths of all the rays lie partly through glass and partly through liquid in nearly the same proportions. The difference of retardations along various rays is thus a question of a deviation from an average.

It is true that we may imagine a relative distribution of glass

and liquid that would more nearly assimilate the two cases. If, for example, the glass consisted of equal spheres resting against one another in cubic order, some rays might pass entirely through glass and others entirely through liquid, and then the quarter wave-length of relative retardation would enter at the same total thickness in both cases. But such an arrangement would be highly unstable; and, if the spheres be packed in close order, the extreme relative retardation would be much less. The latter arrangement, for which exact results could readily be calculated, represents the glass powder more nearly than does the cubic order.

A simplified problem, in which the element of chance is retained, may be constructed by supposing the particles of glass replaced by thin parallel discs which are distributed entirely at random over a certain stratum. We may go further and imagine the discs limited to a particular plane. Each disc is supposed to exercise a minute retarding influence on the light which traverses it, and they are supposed to be so numerous that it is improbable that a ray can pass the plane without encountering a large number. A certain number (m) of encounters is more probable than any other, but if every ray encountered the same number of discs, the retardation would be uniform and lead to no disturbance.

It is a question of probabilities to determine the chance of a prescribed number of encounters, or of a prescribed deviation from the mean. In the notation of the integral calculus the chance of the deviation from m lying between $\pm r$ is (see *Phil. Mag.*, 1899, vol. xlvi. p. 251)

$$\frac{2}{\sqrt{\pi}} \int_0^{\tau} e^{-\tau^2} d\tau,$$

where $\tau = r / \sqrt{(2m)}$. This is equal to .84 when $\tau = 1.0$, or $r = \sqrt{(2m)}$; so that the chance is comparatively small of a deviation from m exceeding $\pm \sqrt{(2m)}$.

To represent the glass powder occupying a stratum of 2 cm. thick, we may perhaps suppose that $m = 72$. There would thus be a moderate chance of a difference of retardations equal to, say, one-fifth of the extreme difference corresponding to a substitution of glass for liquid throughout the whole thickness. The range of wave-lengths in the light regularly transmitted by the powder would thus be about five times the range of wave-lengths still unseparated in a spectroscope of equal (2 cm.) thickness. Of course, no calculation of this kind can give more than a rough idea of the action of the powder, whose disposition, though partly a matter of chance, is also influenced by mechanical considerations; but it appears, at any rate, that the character of the light regularly transmitted by the powder is such as may reasonably be explained.

As regards the size of the grains of glass, it will be seen that as great or a greater degree of purity may be obtained in a given thickness from coarse grains as from fine ones, but the light not regularly transmitted is dispersed through smaller angles. Here again the comparison with the regularly disposed prisms of an actual spectroscope is useful.

At the close of the lecture the failure of transparency which arises from the presence of particles small compared to the wave-length of light was discussed. The tints of the setting sun were illustrated by passing the light from the electric lamp through a liquid in which a precipitate of sulphur was slowly forming (*op. cit.*, 1881, vol. xii. p. 96). The lecturer gave reasons for his opinion that the blue of the sky is not wholly, or even principally, due to particles of foreign matter. The molecules of air themselves are competent to disperse a light not greatly inferior in brightness to that which we receive from the sky.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—The honorary degree of M.A. was conferred in Convocation on Tuesday upon Mr. Roland Trimen, F.R.S.

Convocation has passed the decree accepting the offer of the Royal Geographical Society of 400*l.* for five years for the furtherance of geographical studies in Oxford, and providing an equal contribution from the funds of the University.

CAMBRIDGE.—The following is the speech delivered on May 11 by the Public Orator, Dr. Sandys, of St. John's